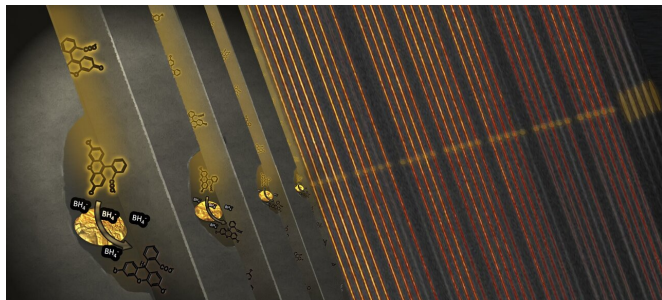


Light at the end of the nanotunnel for future catalysts

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A nanoreactor developed at Chalmers University of Technology visualises the activity of individual catalytic nanoparticles. To identify the efficiency of each particle in the catalytic process, the researchers isolated individual gold nanoparticles in separate nanotunnels. They then sent in two kinds of molecules that react with each other on the particles' surfaces. One molecule (fluorescein) is fluorescent and when it meets its partner molecule (borohydride) the light emission stops upon reaction between the two. This makes it possible to track the catalytic process. Credit: Sune Levin and *Nature Communications*

Using a new type of nanoreactor, researchers at Chalmers University of Technology, Sweden, have mapped catalytic reactions on individual metallic nanoparticles. Their work could improve chemical processes, and lead to better catalysts and more environmentally friendly chemical technology. The results are published in the journal *Nature Communications*.

Catalysts increase the rate of [chemical](#) reactions. They play a vital role in many important industrial processes, including making fuels and medicines, and limiting harmful vehicle emissions. They are also essential building blocks for new sustainable technologies like fuel cells that generate electricity through a reaction between oxygen and hydrogen. Catalysts can also contribute to breaking down environmental toxins by cleaning poisonous

chemicals from water, for example.

To design more effective catalysts for the future, fundamental knowledge is needed, such as understanding catalysis at the level of individual active catalytic particles.

To visualize the difficulty of understanding [catalytic reactions](#) today, imagine a crowd at a football match, where a number of spectators light up flares. The smoke spreads rapidly, and once a smoke cloud has formed over the crowd, it is almost impossible to say who actually lit the flares, or how powerfully each one is burning. The [chemical reactions](#) in catalysis occur in a comparable way. Millions of individual particles are involved, and it is currently very difficult to track and determine the roles of each specific one, including how effective they are and how much each has contributed to the reaction.

It is thus necessary to investigate the catalytic process at the level of individual nanoparticles. The new nanoreactor has allowed the Chalmers researchers to do this. The reactor consists of around 50 glass nanotunnels filled with liquid and arranged in parallel. In each tunnel, the researchers placed a single gold nanoparticle. Though they are of similar size, each nanoparticle has varied catalytic qualities—some are highly effective, others decidedly less optimal. To be able to discern how size and nanostructure influence catalysis, the researchers measured catalysis on the particles individually.

"We sent into the nanotunnels two types of molecules that react with each other. One molecule type is fluorescent and emits light. The light is only extinguished when it meets a partner of the second type on the surface of the nanoparticles, and a chemical reaction between the molecules occurs. Observing this extinction of the 'light at the end of the nanotunnel' downstream of the nanoparticles allowed us to track and measure the efficiency of

each nanoparticle at catalyzing the chemical reaction," says Sune Levin, doctoral student at the Department of Biology and Biotechnology at Chalmers University of Technology, and lead author of the scientific article.

He carried out the experiments under the supervision of Professors Fredrik Westerlund and Christoph Langhammer. The new nanoreactor is a result of a broad collaboration between researchers at several different departments at Chalmers.

"Effective catalysis is essential for both the synthesis and decomposition of chemicals. For example, catalysts are necessary for manufacturing plastics, medicines and fuels in the best way, and effectively breaking down environmental toxins," says Fredrik Westerlund, Professor at the Department of Biology and Biotechnology at Chalmers.

Developing better [catalyst](#) materials is necessary for a sustainable future and there are big social and economic gains to be made.

"If catalytic [nanoparticles](#) could be optimally refined, society could derive enormous benefit. In the [chemical industry](#) for example, making certain processes just a few percent more effective could translate to significantly increased revenue, as well as drastically reduced environmental impacts," says research project leader Christoph Langhammer, Professor at the Department of Physics at Chalmers.

More information: Sune Levin et al, A nanofluidic device for parallel single nanoparticle catalysis in solution, *Nature Communications* (2019). [DOI: 10.1038/s41467-019-12458-1](#)

Provided by Chalmers University of Technology

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